
# Parabolic Trough Workshop

# Cooling for Parabolic Trough Power Plants

## Overview

**Incline Village, Nevada**

**Feb 14, 2006**

U.S. Department of Energy
Energy Efficiency and Renewable Energy

# Water Requirements for Power Generation

## (in Gallons per MWh of Plant Output)

| Plant Type | Steam Condensing | Auxillary Cooling and Hotel Load | Total |
|---|---|---|---|
| **Stand-alone steam plant** | 720[1] | 30[2] | **750** |
| **Simple-cycle gas turbine** | 0 | 150[3] | **150** |
| **Combined-cycle plant (2/3 CT + 1/3 steam)** | 240 (1/3 x 720) | 110 (2/3 x 150 + 1/3 x 30) | **350** |
| **Combined-cycle plant with dry cooling** | 0 | 110 | **110** |
| **Stand-alone steam plant with dry cooling** | 0 | 30 | **30** |
| **Parabolic Trough with wet cooling** | 920[4] | 80[5] | **1000** |
| **Parabolic Trough with dry cooling** | 0 | 80 | **80** |

[1] evaporation + blowdown = 12 gpm/MW

[2] estimated at ~5% of evaporation + blowdown

[3] mid-range of 75-200 gal/MWh for turbine cooling, emissions control and hotel load.

[4] based on historical data from SEGS (higher than conventional because of lower net steam cycle efficiency of SEGS, in part due to HTF pumping and night time parasitics .

[5] Includes make-up water requirements for steam cycle (60 gal/MWh) and solar field mirror wash (20 gal/MWh) data from KJCOC.

# NREL Wet/Dry Cooling Analysis

| | 100 MWe Trough | | | | |
|---|---|---|---|---|---|
| At Kramer Junction Radiation 8.05 kWh/m2/day | **Wet** Cooling | **Dry** Cooling | | | |
| In Service | 2006 | 2006 | | | |
| **Solar Field Area (m2)** | 684,717 | 684,717 | | | |
| | | | | | |
| **Cooling System** | | | | | |
| Tair,d (ºF) | na | 87 | 75 | 65 | 54 |
| ITD (Tcond –Tair,d) (ºF) | na | 22 | 34 | 44 | 55 |
| Capital Cost ($/kWe) | 40[a] | 288 | 193 | 152 | 123 |
| Fan Design Point Parasitics (MWe) | 1.9[b] | 5.6 | 2.8 | 1.9 | 1.6 |
| | | | | | |
| Annual Cooling Parasitics (MWh) | 5,297 | 11,847 | 7,022 | 5,205 | 4,405 |
| Dry Cooling Penalty (MWh) | na | 1,912 | 3,502 | 5,529 | 10,878 |
| Total Plant Parasitics (% of gross) | 12.4% | 14.5% | 13.1% | 12.6% | 12.5% |
| | | | | | |
| Annual Net Capacity Factor | 29.3% | 28.4% | 28.8 | 28.7% | 28.3 |
| Plant Capital Cost ($/kWe) | 3080 | 3328 | 3233 | 3192 | 3164 |
| Operating Costs (k$/yr)[c] | 5292 | 5201 | 5201 | 5201 | 5201 |
| Insurance | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% |
| Levelized Cost of Energy ($/kWh)[d] | 0.119 | 0.131 | 0.126 | 0.125 | 0.126 |
| | **100%** | **110%** | **106%** | **105%** | **106%** |
| **Relative Factors** | | | | | |
| Capital Cost | 100% | 108% | 105% | 104% | 103% |
| Operating Costs | 100% | 98% | 98% | 98% | 98% |
| Annual Performance | 100% | 97% | 98% | 98% | 97% |
| | | | | | |
| Water Use (gal/MWh) | **1000** | **80** | **80** | **80** | **80** |
| | | | | | |

# References

**[1] California Energy Commission, 2002, "Comparison of Alternative Cooling Technologies for California Power Plants Economics, Environmental and Other Tradoffs," CEC 500-02-079F, Feb 2002.**
**http://www.energy.ca.gov/pier/final_project_reports/500-02-079f.html**

**[2] KJC Operating Company, 2002, "SEGS Acquaintance & Data Package," Boron, CA.**